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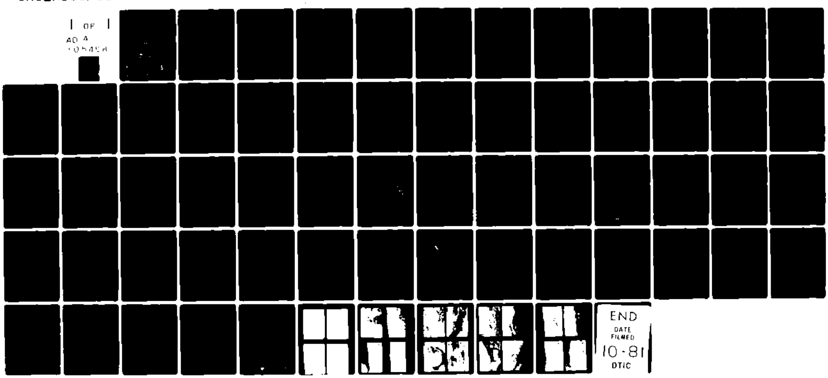

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HOLIDAY LAKE DAM

CRAWFORD COUNTY, MISSOURI

MO 30587

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A105	3. RECIPIENT'S CATALOG NUMBER 456
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Holiday Lake Dam (MO 30587) Crawford County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Anderson Engineering, Inc.		8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0070
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE September 1979
		13. NUMBER OF PAGES Approximately 65
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) National Dam Safety Program. Holiday Lake Dam (MO 30587), Mississippi - Kaskaskia - St. Louis Basin, Crawford County, Missouri. Phase I Inspection Report.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Holiday Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Holiday Lake Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED 20 SEP 1979
Chief, Engineering Division — Date

APPROVED BY: SIGNED 20 SEP 1979
Colonel, CE, District Engineer — Date

A

HOLIDAY LAKE DAM

CRAWFORD COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30587

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

September 1979

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Holiday Lake Dam
State Located:	Missouri
County Located:	Crawford
Stream:	Shoal Creek
Date of Inspection:	26 June 1979

Holiday Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately one-half mile downstream of the dam. Located within this zone are three dwellings and two roads. The dam is in the small size classification, since the maximum storage capacity is greater than 50 ac-ft but less than 1000 ac-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 25 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small size of the dam, the low storage impoundment capacity of the

reservoir and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year frequency flood will not overtop the dam. The 100-y ar flood is one that has a 1 percent chance of being exceeded or equaled in any given year.

Deficiencies visually observed by the inspection team were: (1) some sloughing of the upstream face of the embankment above the riprap; (2) sloughing and large slide area of primary spillway side slopes; (3) few small trees on downstream face of embankment; (4) debris and fallen trees in primary spillway discharge channel; (5) some debris in emergency approach channel; (6) some erosion in emergency spillway; and (7) erosion around the wing walls of the primary spillway control structure. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steve Brady
Steve Brady, P.E. (AEI)

Dave Daniels
Dave Daniels, P.E. (HEI)

Nelson Morales, P.E. (HEI)

Tom Beckley
Tom Beckley, P.E. (AEI)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOLIDAY LAKE DAM - ID No. 30587

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Holiday Lake Dam in Crawford County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Holiday Lake Dam is an earth fill structure approximately 24 ft high and 380 ft long at the crest. The appurtenant works consist of: (1) a rock cut primary spillway with concrete control structure located at the west abutment, (2) a grass-covered earth swale emergency spillway located at the east abutment, and (3) a 6 in. diameter steel drawdown pipe and valve located near the center of the dam. Sheet 3 of Appendix A shows a plan, profile and typical section of the embankment.

B. Location:

The dam is located in the southeastern part of Crawford County, Missouri on Shoal Creek. The dam and lake are within the Davisville, Missouri 7.5 minute quadrangle sheet (Section 10, T35N, R2W - latitude 37° 45.6'; longitude 91° 07.6'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 24 ft and a maximum storage capacity of approximately 136 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately half a mile downstream of the dam. Located within this zone are three dwellings and two roads.

E. Ownership:

The dam is owned by Mr. Eugene Renna. The owner's address is 517 South Idyllwild Avenue, Rialto, California 92376.

F. Purpose of Dam:

The dam was constructed primarily for recreational purposes, although some flood protection is also provided.

G. Design and Construction History:

According to the owner, handwritten design specifications for the construction of the dam were prepared by an engineer (name unknown). An attempt to obtain a copy of these design specifications was unsuccessful. The owner reported by telephone that the specifications consisted of the following items:

1. A 10 ft top width with front and back slopes at 3H:1V.

2. Clay key (20 ft bottom width) to extend to impervious material (clay or rock) and clay core to extend to water line.

3. Embankment to be compacted to "95% density."

4. Embankment material can be of lesser quality downstream of core.

5. The permanent spillway should be 1.5 ft below the emergency spillway with 5 ft of freeboard.

6. Permanent spillway-10 ft wide with 2H:1V side slopes.

7. Emergency spillway-120 ft wide with 3H:1V side slopes.

8. Dam should have a 1 ft crown above freeboard.

The owner indicated that the subsurface materials were investigated by means of backhoe cuts made before construction of the dam.

The dam was constructed in 1972, by Mr. Jerry Martin of Steelville, Missouri. Material for construction of the dam was a clayey soil obtained from the hillside at the east abutment, the emergency spillway area and from the lake area.

The lake has apparently leaked since construction, although dye tests and backhoe investigations failed to locate the source or path of the leakage (see Sheets 3 through 8 of Appendix B). The builder of the dam (Jerry Martin) indicated that in 1973 a clay blanket was placed in the lake area about two thirds the distance from the dam to the upstream reaches of the lake (blanket about 1/2 acre in area). This small clay blanket was placed in an area where a test boring had been made by a mining company. It was believed that this test boring had not been properly sealed, and was providing a path for seepage. The owner (Mr. Renna) indicated that the lake level dropped 12 ft during the summer of 1975. The caretaker indicated that the lake level dropped about 13 in. in the three weeks previous to our site inspection. No seepage through the dam has been reported, and the leakage is believed to be passing beneath the dam. The only known modification to the dam was the construction of the concrete control section of the primary spillway in 1975.

H. Normal Operating Procedures:

All flows will be passed by uncontrolled spillways (see Sheet 3, Appendix A). The caretaker (who lives at the site) indicated that the emergency spillway has operated twice since construction of the dam. Most recently (April 1979), the water was 6 in. to 12 in. deep over the emergency spillway crest. The owner indicated that the maximum experienced flood at the dam was in 1975 or 1976, when the water passing over the emergency spillway was about 18 in. deep. It is not known whether the 6 in. drawdown pipe has ever been used, although a small plunge pool below the outlet suggests that it has been used.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 909 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways (does not include flows through the 6 in. gated drawdown pipe).

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 1071.8): 2538 cfs

(3) Estimated Capacity of Primary Spillway: 518 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: 650 cfs at Elev. 1069.7

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed M.S.L. elevation of 1071.0 (site datum elevation 100.00) for the top of the east end of the concrete wing wall at the primary spillway (see Sheet 3, Appendix A).

(1) Top of Dam: 1071.8 (Low Point); 1072.2 (High Point)

(2) Principal Spillway Crest: 1067.0

(3) Emergency Spillway Crest: 1068.2

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 1048.0

(6) Pool on Date of Inspection: 1066.3

(7) Apparent Recent High Water Mark: 1068.9

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 2100 ft

(2) At Principal Spillway Crest: 1500 ft

(3) At Emergency Spillway Crest: 1650 ft

E. Storage Capacities:

(1) At Principal Spillway Crest: 70 ac-ft

(2) At Top of Dam: 136 ac-ft

(3) At Emergency Spillway Crest: 87 ac-ft

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 11 acres

(2) At Top of Dam: 17 acres

(3) At Emergency Spillway Crest: 12.5 acres

G. Dam:

(1) Type: Earth

(2) Length at Crest: 380 ft

(3) Height: 24 ft

(4) Top Width: 11 ft

(5) Side Slopes: Upstream Irregular; Downstream Irregular (see Sheet 3, Appendix A)

(6) Zoning: Homogeneous with clay core (from Jerry Martin)

(7) Impervious Core: 15 ft wide in center of dam--extends to slightly above normal pool (from Jerry Martin)

(8) Cutoff: 6 ft to 20 ft deep and about 20 ft wide at the base (from Jerry Martin)

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: West Abutment

(2) Type: Rock cut with rectangular concrete weir

I.2 Emergency Spillway:

(1) Location: East Abutment

(2) Type: Grass-covered earth swale

J. Regulating Outlets:

There are no regulating facilities associated with this dam. The only dewatering facility is a 6 in. diameter steel pipe located near the center of the dam. Flows from the dewatering pipe are controlled by a valve located near the downstream toe of the embankment.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No design computations for Holiday Lake Dam were obtained.

The owner transmitted design specifications by telephone, although a copy of these specifications could not be obtained. The only reports obtained were a pre-construction engineering geologic report and post-construction reports prepared by the Missouri Geological Survey (Sheets 3 through 8, Appendix B). No documentation of construction inspection records has been obtained. To our knowledge, there are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys was obtained. Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. The top of the east end of the concrete wing wall at the primary spillway was used as a site datum of assumed M.S.L. elevation 1071 (site datum elevation 100.00) as derived from U.S.G.S. quadrangle map and survey information (see Sheet 3, Appendix A).

B. Geology and Subsurface Materials:

The site is located in the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert.

Information supplied by the Missouri Geological Survey indicates that the bedrock in the valley consists of the Potosi formation of the Cambrian System. The Potosi formation is composed of a massive, thickly bedded, medium-to fine-grained dolomite. Caves, springs, seeps and other solution phenomena are common to the Potosi formation. The publication "Caves of Missouri" lists seven caves known to exist in Crawford County. All but one of these caves are clustered in a nine square mile area about 17 miles northwest of the site. Caves listed in adjacent counties are greater distances from the site.

The "Geologic Map of Missouri" indicates a normal fault passing about 5 miles north of the site in an east-west direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years.

Soils in the area of the dam site appear to be primarily thin deposits of residual silty clays with rock fragments. The soils are of the Clarksville-Fullerton-Talbott Soil Association and have developed from thin loessial soils deposited over weathered material from cherty dolomites. The loessial thickness map indicates that upland areas may have between 2.5 and 5.0 ft of loess cover.

C. Foundation and Embankment Design:

The following foundation and embankment design specifications were prepared by an engineer (name unknown) for the owner:

1. A 10 ft top width with front and back slopes at 3H:1V.

2. Clay key (20 ft bottom width) to extend to impervious material (clay or rock) and clay core to extend to water line.

3. Embankment to be compacted to "95% density."

4. Embankment material can be of lesser quality downstream of core.

Information from Jerry Martin (builder of dam) indicates that the key trench under the dam is 6 ft to 20 ft deep and approximately 20 ft wide at the base. The key extends to bedrock in the middle and extends a few ft into "good clay" in abutment areas. There is a 15 ft wide clay core in the middle of the cross section which extends to slightly above normal pool level. There are three antiseep collars on the drawdown pipe under the dam, one in the middle and one on either end spaced more or less equidistant from each other.

Seepage and stability analyses apparently were not performed as required in the guidelines. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist. No construction inspection test results have been obtained.

D. Hydrology and Hydraulics:

The following design specifications were prepared for the owner by an engineer (name unknown):

1. The permanent spillway should be 1.5 ft below the emergency spillway with 5 ft of freeboard.

2. Permanent spillway-10 ft wide with 2H:1V side slopes.

3. Emergency spillway-120 ft wide with 3H:1V side slopes.

4. Dam should have a 1 ft crown above freeboard.

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 7. It was concluded that the structure will pass 25 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

No design information for the concrete weir structure at the primary spillway was obtained.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION AND MAINTENANCE:

Normal flows are passed by an uncontrolled rectangular concrete weir primary spillway located at the west abutment. The grass-covered earth swale emergency spillway located at the east abutment operates during periods of excess flows. Despite the presence of some small trees on the downstream face of the embankment, it appears that the dam has been maintained.

2.4 EVALUATION:

A. Availability:

The only engineering data available are as listed in Section 2.1. No seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on June 26, 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Nelson Morales - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

B. Dam:

The dam appears to be generally in good condition. Some sloughing of the upstream slope above the riprap was noted. The riprap consists of concrete and rock rubble from old buildings. A few small trees were observed on the downstream face of the embankment. The horizontal and vertical alignments of the crest are good. No surface cracking of the embankment was noted. Shallow auger probes into the embankment indicated the dam to consist of a reddish brown silty clay with rock fragments. Information from the builder indicates that the borrow material for construction of the embankment was obtained from the hillside in the east abutment area, the emergency spillway area and the lake area.

Although water has leaked from the lake since construction of the dam, no seepage through the embankment was noted during the inspection. The contact of the primary spillway and the embankment has eroded somewhat. No instrumentation (monuments, piezometers, etc.) was observed.

It should be noted that a sewer line apparently passes through the west end of the embankment at or near the west abutment in a general north-south direction. The location of a manhole associated with this sewer is shown on Sheet 3, Appendix A.

C. Appurtenant Structures:

C.1 Primary Spillway:

The approach channel of the primary spillway was fairly clear. The concrete weir structure is in good condition. The side slopes of the primary spillway outlet channel have eroded severely, and a rather large slide and several smaller sloughs were observed in this area. Debris and fallen trees were also observed in the spillway outlet channel.

C.2 Emergency Spillway:

A small amount of debris was present in the approach channel of the emergency spillway. A slight amount of erosion was observed in the emergency spillway.

C.3 Drawdown Pipe:

The 6 in. diameter steel drawdown pipe and valve appeared to be in good condition. A small plunge pool has eroded at the outlet of the drawdown pipe.

D. Reservoir:

The watershed is generally wooded, with no agricultural activity. The slopes adjacent to the reservoir are moderate, and no sloughing or serious erosion was noted.

E. Downstream Channel:

The side slopes of the primary spillway discharge channel have eroded, and some serious sloughing of the side slopes was observed. Debris and fallen trees were present in the downstream channel.

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. The sloughing on the upstream face of the dam and the sloughing and slides in the sides of the primary spillway discharge channel indicate that the erosion resistance is inadequate in these areas. The eroded area at the primary spillway control section-embankment contact could endanger the spillway control section if not corrected. Debris and fallen trees in the primary spillway discharge channel and the approach channel of the emergency spillway can significantly restrict flood flows.

The above deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

Because the valve of the lake drain is located on the downstream side of the dam, the full head of water impounded by the dam is acting entirely through the dam. The area around the lake drain outlet should be periodically inspected for seepage which might indicate a leak or rupture of the drain pipe and could eventually initiate a piping failure through the embankment.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

Although there is a drawdown pipe under this dam, no regulating procedures are known to exist. The pool is normally controlled by rainfall, runoff, evaporation, the capacities of the uncontrolled spillways, and the leakage from the reservoir.

4.2 MAINTENANCE OF DAM:

The presence of some small trees on the downstream face of the embankment and some sloughing on the upstream face indicate that the dam has not been maintained recently.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The drawdown pipe and valve appeared to be in good condition. No regular maintenance program for the dewatering facility is known to exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The trees and brush on the embankment, the brush and debris in the approaches to the spillways and in the outlet channels, and the erosional areas and sloughs on the upstream face of the embankment and the side slopes of the primary spillway are serious deficiencies which should be corrected. However, these should only be accomplished under the direction of an experienced engineer to avoid creating an unsafe condition.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. The caretaker (who lives at the site) reported that the emergency spillway has operated twice since construction of the dam. Most recently (April 1979), the water was 6 in. to 12 in. deep over the emergency spillway crest. The owner indicated that the maximum experienced flood at the dam was in 1975 or 1976, when the water passing over the emergency spillway was about 18 in. deep. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

Considerable erosion and sloughing have occurred along the embankment and the outlet channel in the vicinity of the primary spillway structure. This erosion is primarily due to the lack of a proper energy dissipator and the lack of adequate bank protection. Debris and material eroded from the area has been deposited in the outlet channel which obstructs the channel and reduces its hydraulic efficiency.

The spillway channels are well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 25 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small size of the dam, the

low storage impoundment capacity and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The structure will pass a 100-year frequency flood without overtopping.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will be overtopped by 1.34 ft at elevation 1073.14. The duration of the overtopping will be 0.92 hours, and the maximum outflow will be 6006 cfs. The maximum discharge capacity of the spillways is 2538 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

The only design and construction data obtained were the design specifications presented in Sections 1.2G and 2.1C & D. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The only reported post-construction change was the addition of the concrete weir control section for the primary spillway in 1975.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) erosion of material around the wing walls at the primary spillway control structure; (2) slides and sloughing of the primary spillway discharge channel side slopes; (3) some sloughing of the upstream embankment face above the riprap; (4) debris and fallen trees in primary discharge channel; (5) small trees present on the downstream embankment face; (6) debris in emergency spillway approach channel; and (7) some erosion of the emergency spillway outlet channel.

The dam will be overtopped by flows in excess of 25 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by the owner and caretaker, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will

deteriorate and possibly could become serious in the future. Priority should be given to increasing the size of the spillway.

D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

(2) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(3) The wing walls of the primary spillway control structures should be extended into the abutment and embankment to prevent future erosion around the ends of the structure.

(4) The sloughing of the upstream embankment face should be repaired, and additional wave protection should be provided.

(5) A specially designed energy dissipator and proper erosion protection of the primary spillway outlet channel should be provided.

(6) The trees and brush should be removed from the embankment face. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam. Brush and tree growth should then be removed from the dam on an annual basis.

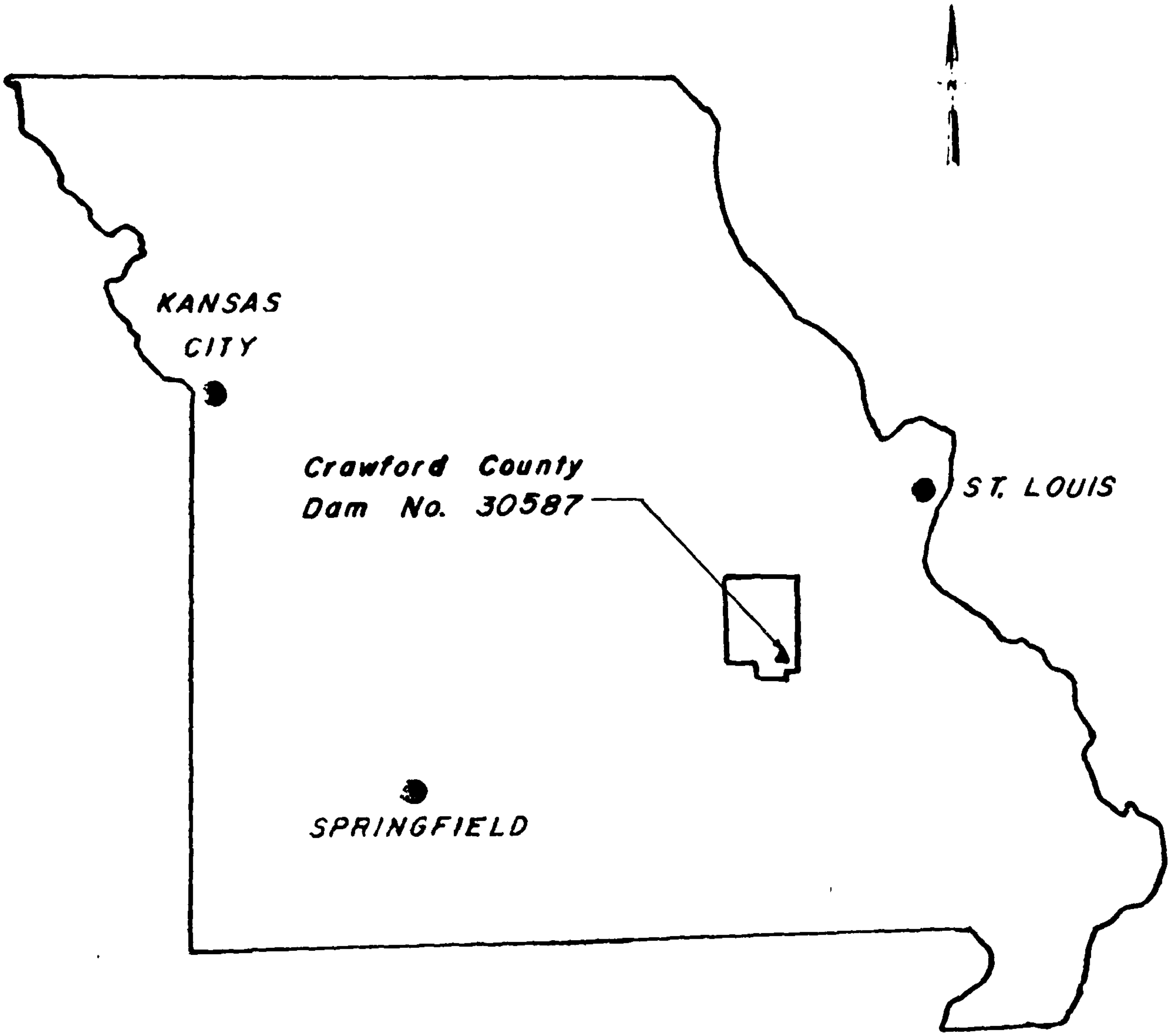
(7) The debris in the approach channel of the emergency spillway should be removed.

(8) The erosional areas in the emergency spillway should be repaired and maintained.

(9) The valve on the drawdown pipe should be opened periodically to insure that it is operable.

(10) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

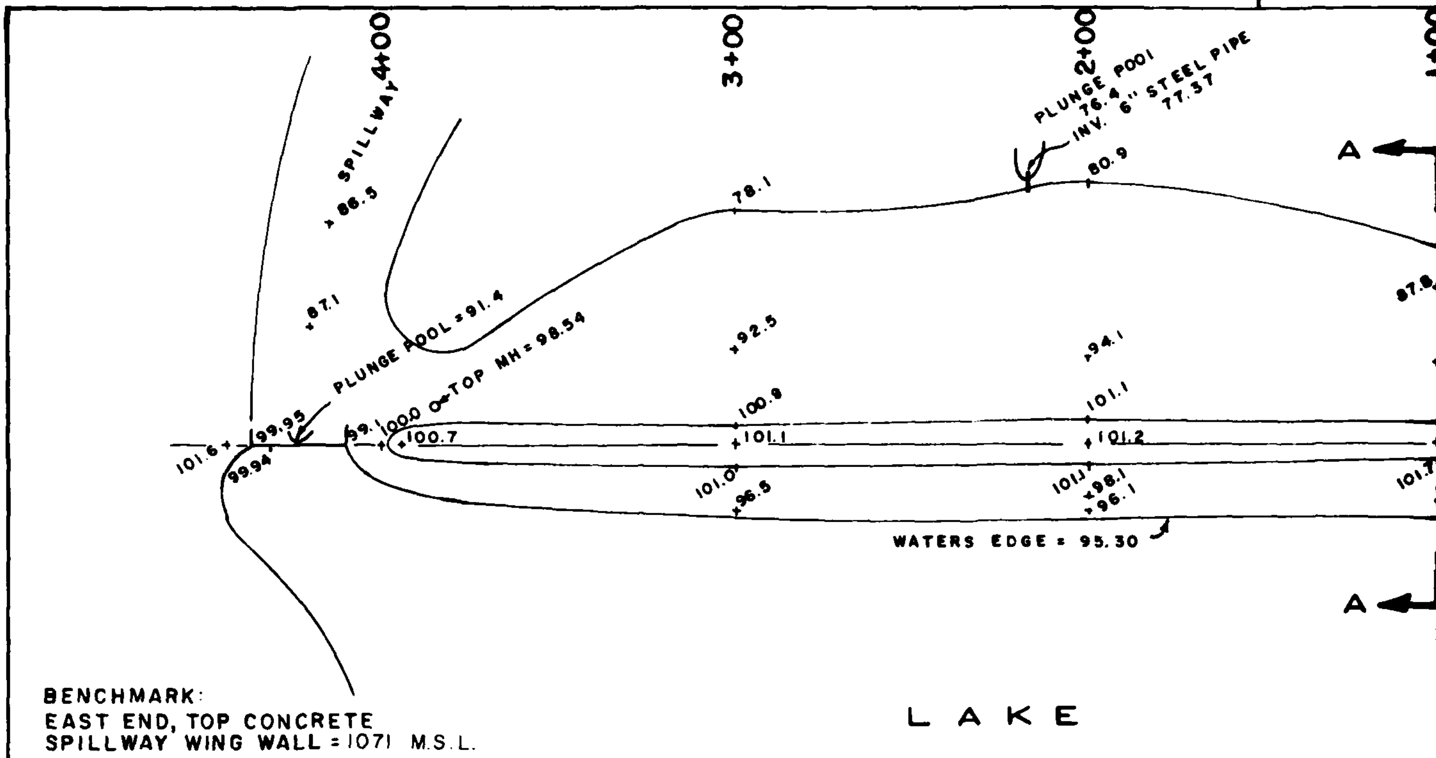
APPENDIX A



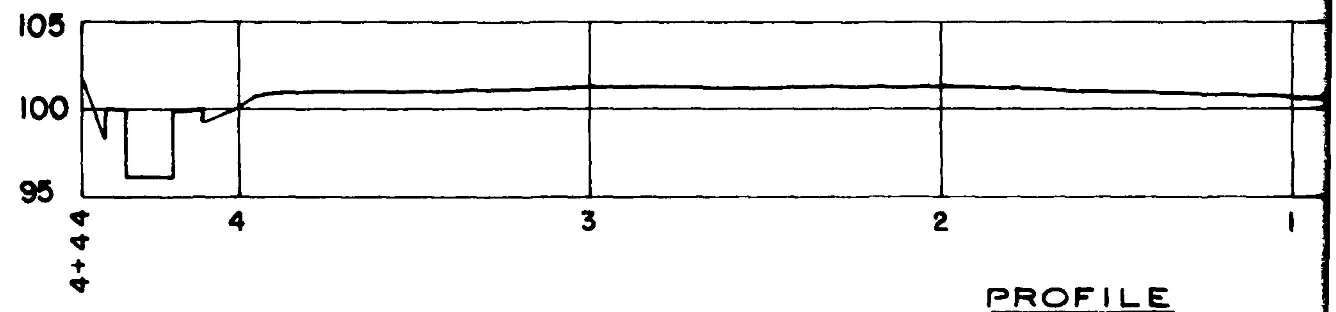
LOCATION MAP

SHEET 1 OF APPENDIX A

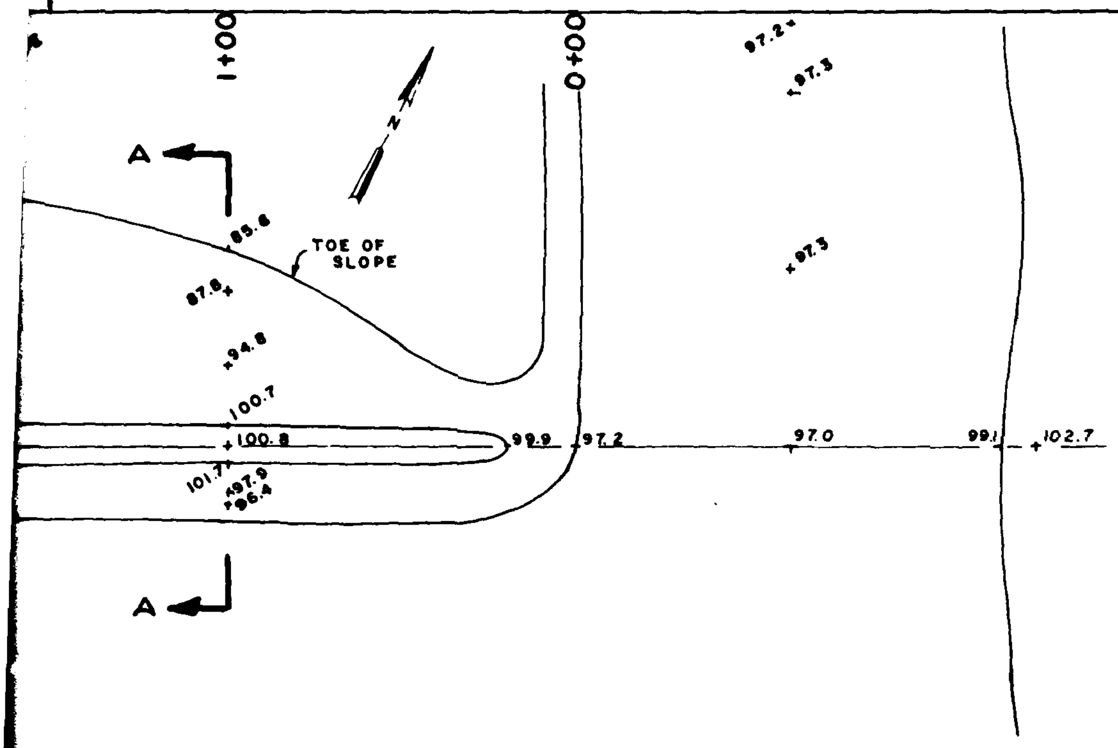
SITE VICINITY MAP

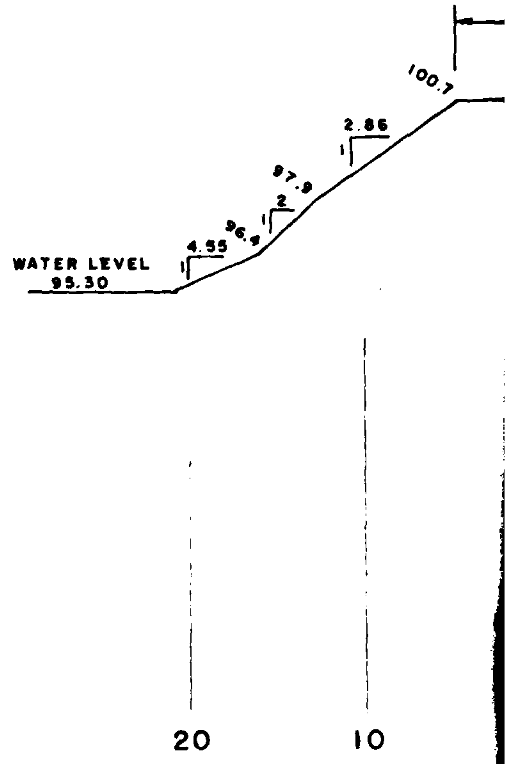


PLAN VIEW
SCALE: 1" = 50'

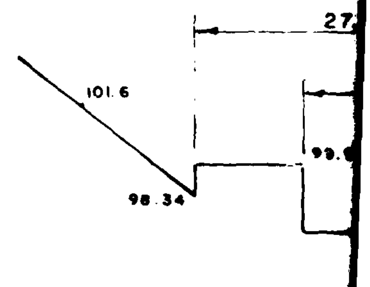


PROFILE

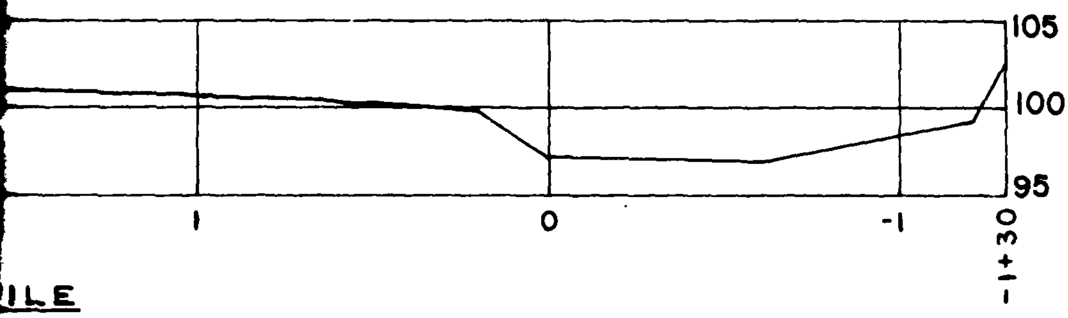




SECTIO



PROFILE O



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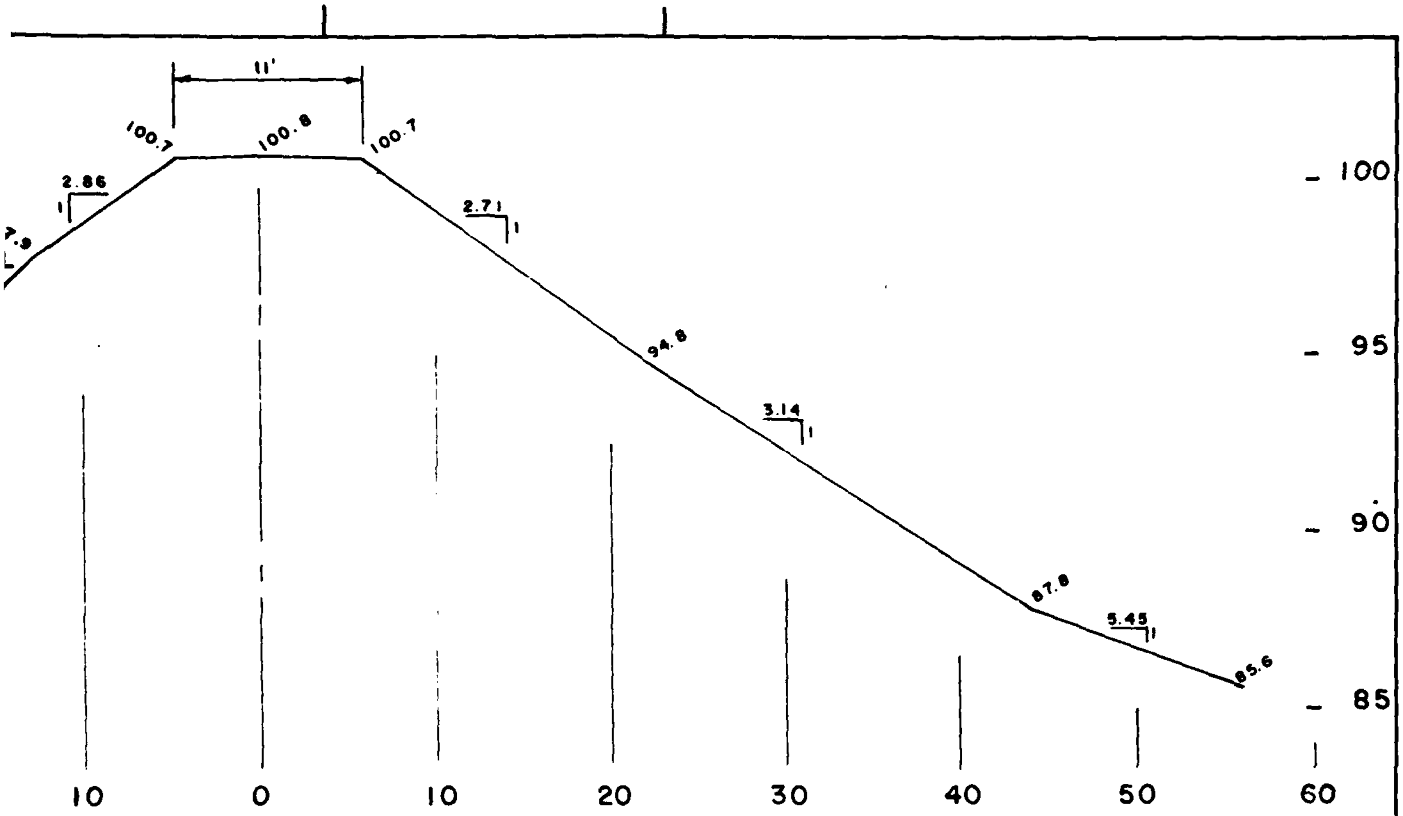
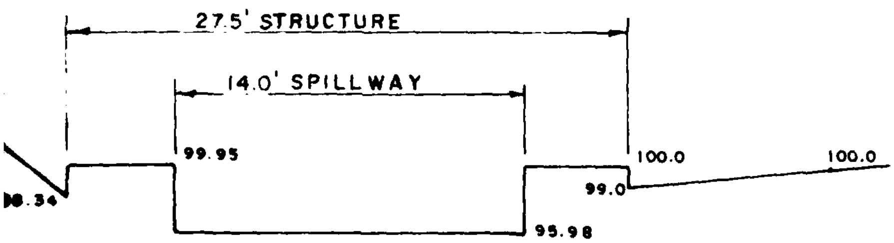


SECTION A - A STA 1+00



ROFILE OF WEST SPILLWAY

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

HOLIDAY LAKE

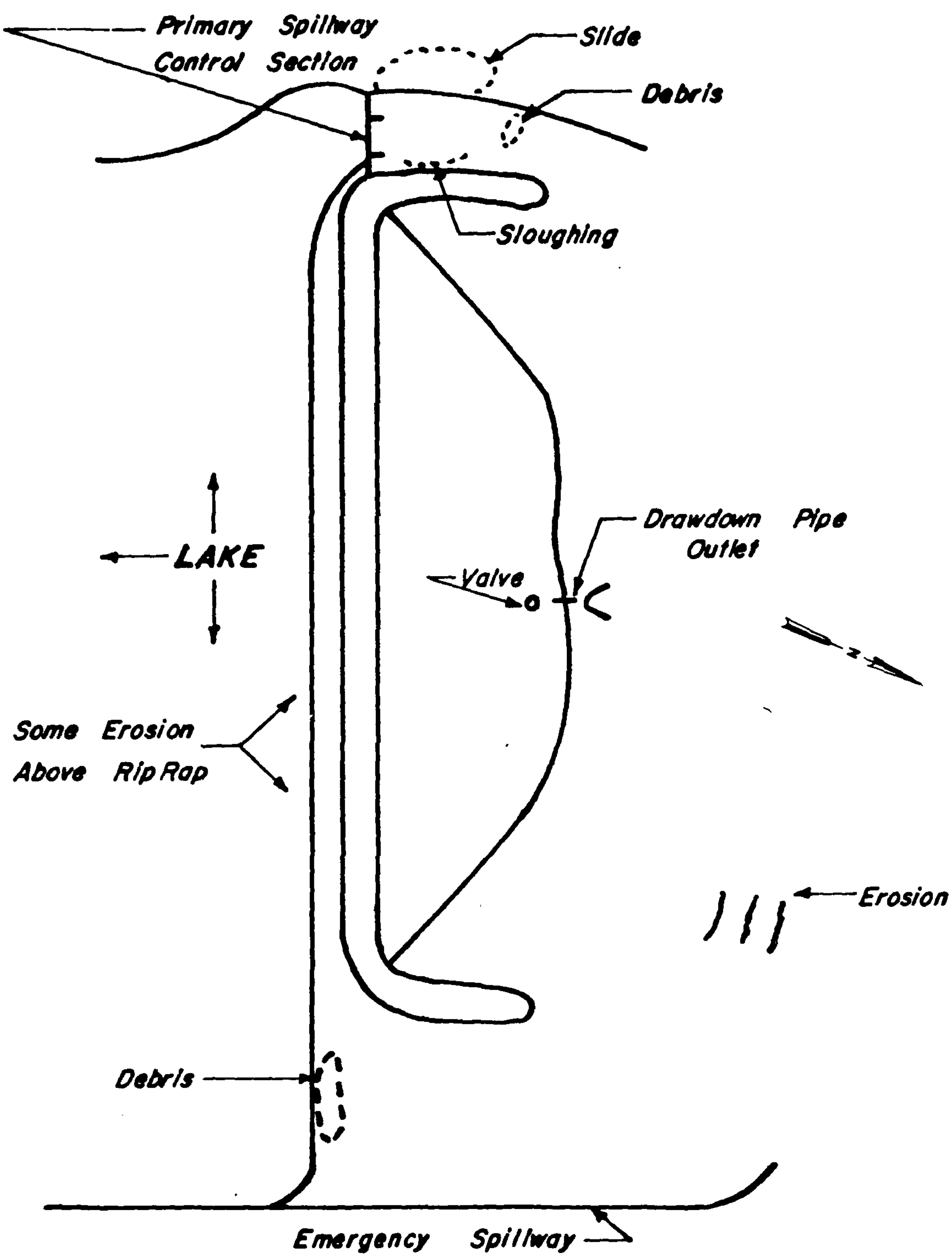
MO. No. 30587

PLAN & PROFILE

CRAWFORD COUNTY, MO.

Sheet 3 of Appendix A

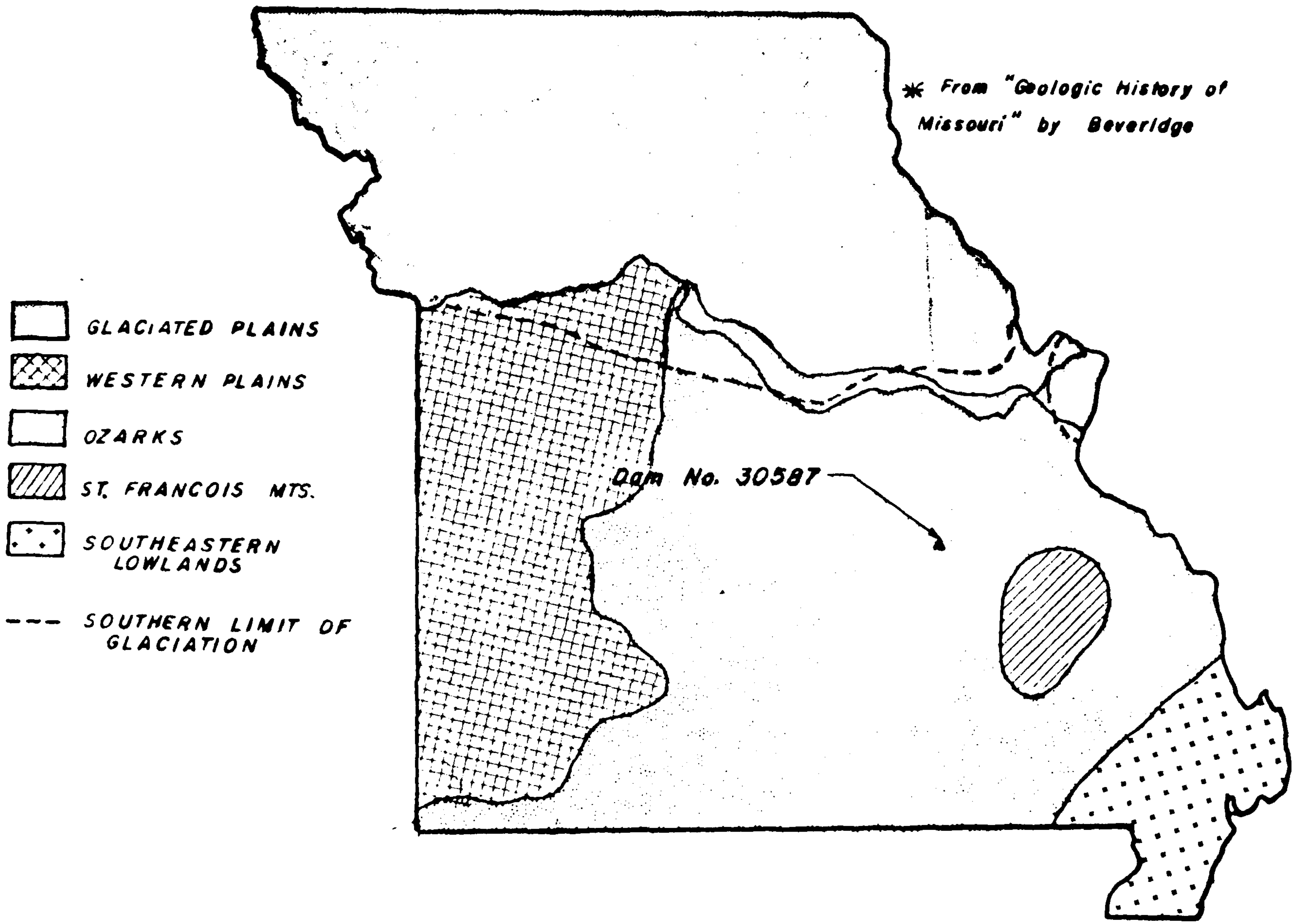
13



DRAWN DER CHECKED DLK DATE 8-1-79 JOB NO. 79511	HANSON ENGINEERS SPRINGFIELD ILL. PEORIA ILL.	Plan Sketch Inspection Observations Sheet 4 Appendix A

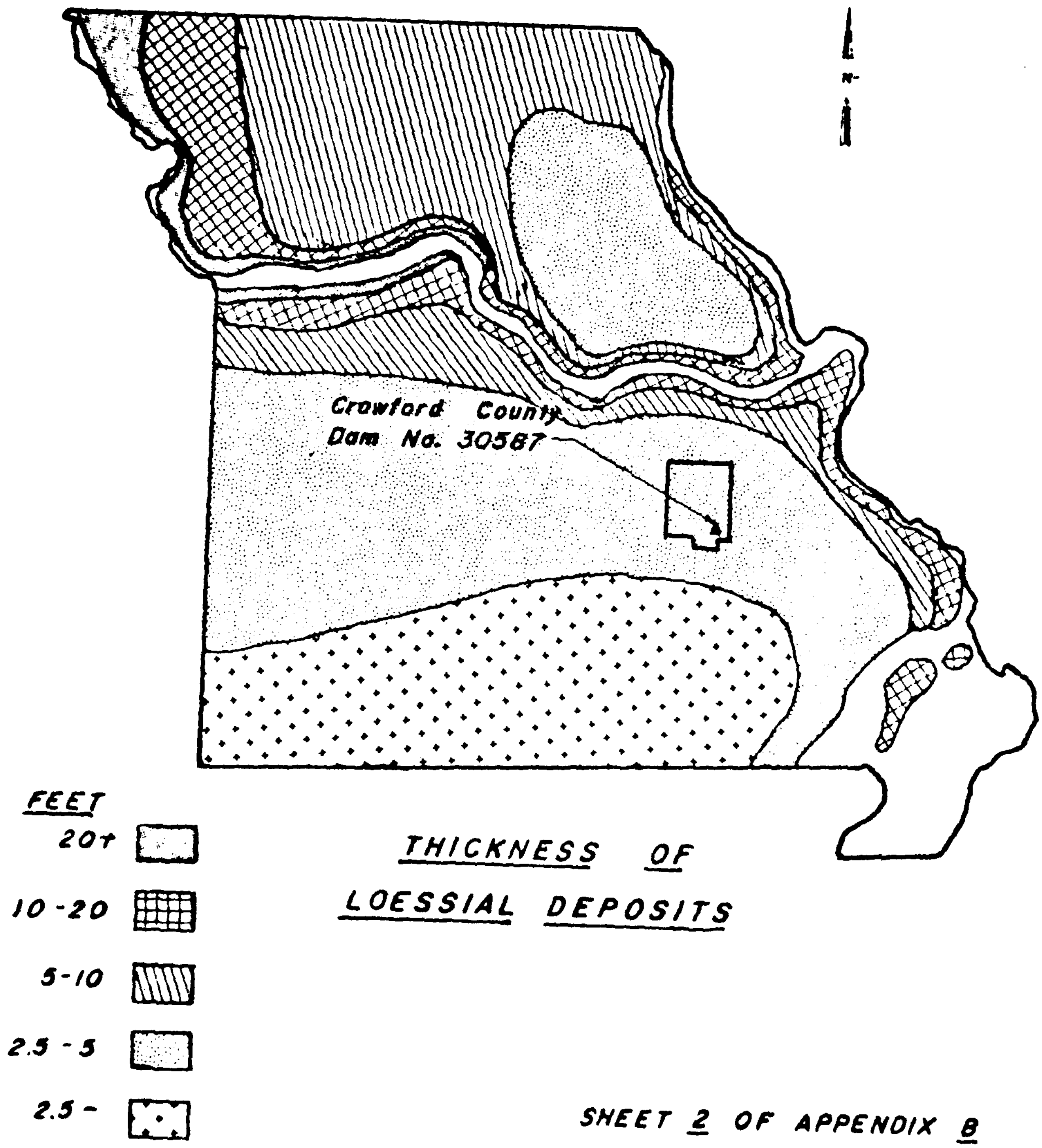
APPENDIX B

MAJOR GEOLOGIC REGIONS OF MISSOURI



SHEET 1 OF APPENDIX B

* From "Soils of Missouri"



THICKNESS OF LOESSIAL DEPOSITS

ENGINEERING GEOLOGIC REPORT ON ... LAKE SITE

Crawford County, Missouri

LOCATION: Center NE¼ Sec. 10, T. 35 N., R. 2 W. (Berryman Quad)

GEOLOGIC SUITABILITY: Favorable and recommended for consideration as a lake site.

GEOLOGIC SETTING:

The valley is underlain by the Potosi dolomite. The bedrock exposures are numerous along the stream channel. Fewer present on the hillslope because of the mantle or covering of residual soil derived from the weathering of the Potosi. The Potosi is a massive, densely fractured dolomite (magnesium rich limestone). Caves, springs, seeps, and other solution phenomena are common to the Potosi. Numerous springs in the valley upstream of the dam site as well as in the immediate vicinity of the dam exist. Also, several seeps occur downstream together with one large spring, all typical of the Potosi.

Generally speaking, the bedrock surface is relatively smooth, although pinnacling including massive nobs of protruding bedrock exist in more weathered areas. Care should be given during exploration and during the core trench excavation to watch for and remove the soft weathered portions of the Potosi dolomite if they should exist.

Although pinnacling, solution enlargement openings and the like are common of the Potosi, these characteristics were not observed in the rock exposures apparent in the stream channel. Some exploration conducted with the backhoe indicated that bedrock remained at a relatively shallow depth on the valley slope. Further exploration is needed to confirm this statement, but it does imply that the bedrock has not been deeply weathered even on the valley slopes.

Soil developed on the bedrock is, for the most part, a stony red clay. However, some exploration completed in the stream valley downstream of the dam site indicates that plastic brown and gray gravelly clay (CC) also occurs. Depth of the soil cover can only be estimated at present, but it appears to range from 3 to perhaps as much as 15 feet.

RECOMMENDATIONS:

It is believed that most of the needed exploration information could be acquired from numerous backhoe exploration pits. These exploration holes should be dug with the intent to determine both physical characteristics of the subsoil as well as depth to bedrock. In addition, some long exploration trenches should be dug across the valley floor to determine both soundness of the underlying bedrock as well as the surface profile. If the bedrock locally is deeply weathered, pinnacled and has extended linear solution openings, then obviously problems would exist with regard to the probability of retaining impounded water. However, if the exploration further confirms the surface appearance that the bedrock is sound, then site characteristics are more favorable for dam construction.

Some exploration pits should be dug on the valley slopes to verify depth to sound bedrock. It is important that the core trench be deepened to bedrock across the entire length of the dam including the abutments. Consequently, it is thus important to determine the depth to bedrock on the abutment slopes, but also the soundness of bedrock. Typically, bedrock may be more weathered near the lower portions of the valley slope. It is important that this weathered bedrock be removed during the construction process so that seepage does not occur in this region.

The possibility of leakage into a solution opening in the Potosi dolomite cannot be discounted. Obviously there are such openings, otherwise numerous springs in the valley would not exist. From the optimistic tone, of this characteristic of the rock, the seasonal flow from these springs, contributes to the gaining watershed and stream channel characteristics within the lake site area. This is a favorable feature in as much as it gives evidence toward groundwater support for the lake. Nevertheless, water could be lost by an individual solution openings. In order to verify this, it would be necessary to drill numerous exploration holes some 20 to 40 feet into bedrock. Because these openings appear to be randomly scattered, there might be some question as to whether this extensive subsurface exploration would be warranted considering the size of the dam.

Areas used for borrow dirt in dam construction should not be extended to great depths beneath the water line, especially near the abutment slopes. It is important that a minimal pad of soil be left as a protective blanket to reduce seepage rates into the subsoil and then into the underlying bedrock. Padding of the stream channel a short distance, 100 to 200 feet, upstream of the toe of the dam would also assist in reducing the problems of seepage within the immediate area of the dam.

If backhoe exploration pits indicate that there is an irregular bedrock surface and that there are zones which are deeply weathered, then it would be important to consider the need for subsurface foundation drilling. If weathered zones of the bedrock are extensive, consideration should be given to abandoning the project for purposes of water impoundment.

It is suggested that the center line of the dam be located slightly upstream of the most narrow point in the valley slope. This would place the center line of the dam in a small draw on the left (west) abutment and on the southward facing slope of the right (east) abutment. This would reduce the depth needed to excavate the core trench to sound bedrock. It would also lengthen the path of seepage and further reduce the problems of leakage from the lake. Surface divergence of the stream flow in the small gully on the left abutment, will have to be considered in this suggested relocation.

James H. Williams
Geologist and Chief
Engineering Geology Section
Missouri Geological Survey
July 20, 1972

ENGINEERING GEOLOGIC REPORT ON RENNA LAKE SITE

CRAWFORD COUNTY, MISSOURI

LOCATION: Dam site in SE¼, NE¼, Sec. 10, T. 35 N., R. 2 W., Berryman Quadrangle.

The 10-12 acre lake constructed several years has a persistent leak causing a draw down of ¼ to 1 inch per week according to the owner. The water level was down approximately 4-6 feet below the spillway on the date of this investigation.

The drainage area encompasses approximately 860 acres and would be a high drainage area for a lake of this size. Although the stream bed upstream of the dam did not have surface flow, it is anticipated that water is moving down the valley in the thick gravelly alluvium.

Dolomite of the Potosi Formation is the parent bedrock in the valley bottom. Remnants of Eminence Dolomite is present in the valley slopes and ridgetops. The Eminence is evidently extensively weathered, resulting in a deep mantle of residual clay covering a highly pinnacled bedrock surface. The dolomite in the valley bottom appears to be essentially flat lying with no unusual weathering characteristics.

Large quantity of water can be seen in the stream bed and in the alluvial material, immediately downstream of the dam in the valley bottom. While the total water flow could not be measured, the quantity is such that if it were cut off upstream of the dam, it should add sufficient water to the lake to prevent a drop in the water line during dry weather.

The alluvium in the valley bottom from just downstream of the dam on the east side is wet while the area of the original channel near the principal spillway side appears to be relatively dry. The flow through the gravel and rock comes into the creek from 50-100 yards downstream of the dam.

While the dolomite of the Potosi can be highly weathered with large solution channels, the primary concern would be to the upper 1-3 feet of bedrock in the valley bottom that will carry water horizontally down the valley through open bedding planes between individual rock layers. This rock is normally removed in the core area of the dam during construction with clay for the core compacted on firm fresh rock rather than the extensively weathered surface rock normally present in the valley bottom.

Water may well be moving out of the valley through solution enlarged features, particularly bedding planes within the lake basin. No evidence of this was seen on the date of this investigation. Mineral test wells were reported to be present in the valley bottom and valley slope on the west side. The well in the valley bottom, according to Mr. Renna, was plugged with neat cement and concrete with the additional wells assumed to be up out of the lake area.

The wells, according to Mr. Renna, indicated a very deep soil section above bedrock. The well in the valley bottom within the lake is reported to have a thickness of 10 feet. If these soil thicknesses are true, some very highly weathered rock is present in the valley bottom. This extremely weathered condition could be contributing to water loss in the lake basin.

In summary, while leakage problems in the lake area not associated with the dam may well be present, it is anticipated that a sufficient quantity of water is moving under the dam at a shallow depth to cause the fluctuation in the water line. To correct this problem, the following procedures are recommended:

1) A dye program could be initiated to verify that the water in the stream and in the lake are connected to the source of the water in the valley bottom immediately below the dam.

2) If water is moving under the dam at a shallow depth, it could be intercepted by at least two different methods. One method would be to drill down through the top of the dam into bedrock 4-5 feet and then interjecting neat cement, grout, or other sealers into the rock. The second method would be to construct a new core on the lower slope of the dam by excavating through the toe of the dam and then blasting a core trench into rock to a depth of anywhere 1-5 feet in depth. This trench would be then backfilled with clay and lapped up onto the dam. The ideal place to put the new core would be on the upstream toe but this would require a lowering of the water level to where the lake would be essentially dry. The constructed core could be put on the lower toe of the slope, but this would require lapping the core up on the face of the dam to a sufficient height to prevent water that is now coming from under the dam from hitting the core and rising and going over the top of the new core on the downstream side. The core, therefore, on the upstream toe of the dam would effectively cut off the water prior to its getting under the dam and thus would be more effective.

After the dye testing has shown relationship between lake water and the water downstream of the dam, then some backhoe work could be done in the valley just below the toe of the dam, to try to determine what portion of the core is allowing water to escape from the lake. The entire core may well not have to be redone. A certain portion particularly on the east side may be the worst water loss area. Cutting a trench down to rock up the valley wall to the east may indicate which area is contributing the most water. This backhoe trench through the alluvium to the top of the bedrock will only indicate the amount of water present on top of the rock and will not indicate the amount present within the upper couple of feet of rock, particularly in the valley bottom. The assumption here is that the majority of the water will be in the bedrock with lesser amounts following the top of the bedrock. It is possible, however, that large quantities of water are moving on top of the bedrock under the core of the dam and the trench work would indicate what areas would need to be grouted or possibly re-cored. It is possible that the water loss is taking place in an area of 10-20 feet in length and as such a re-core of the entire dam would not be necessary.

Thomas [illegible] Dean, Geologist
Applied Engineering & Urban Geology
[illegible] Survey
August [illegible]

SHEET 6 APPENDIX

orig: Gene Renna, [illegible]
Box [illegible], Viburnum cc: [illegible], Conservation, Potosi

H[illegible] Lake

CHRISTOPHER S. BOND
GOVERNOR

JAMES L. WILSON
DIRECTOR

missouri department of natural resources

P O Box 176 Jefferson City, Missouri 65101 314-751-3332

October 14, 1976

Please reply to:
P. O. Box 250
Rolla, MO 65401

Gene Renna
Holiday Lake
Star Route 286
Box 15
Viburnum, MO 65566

Dear Mr. Renna:

No trace of the dye placed in your lake has been picked up in the charcoal packets (bugs) as of this date. I do not know if you have any bugs left down there but you can discontinue sending them in as I doubt seriously whether we will pick up the dye at this late date. While no dye was picked up, I still feel that a considerable amount of leakage is taking place under and around the dam and we did not pick up the dye in the charcoal because of a dilution factor or we did not place the bugs in the right place.

The potential for leakage around the test well in the valley bottom that you mentioned on the phone is certainly worth considering. Although as you described to me, you plugged the wells with cement and/or other products, the leakage potential on the outside of the casing is extremely high, particularly in a setting in the valley bottom. If water from the lake is in fact moving down the outside of the casing to some depth, the water would not necessarily emerge in the valley bottom downstream of the dam but rather could move out into the hillsides in any direction.

To test for the possibility of vertical water movement, I would suggest you dig a hole on the outside of the casing to a depth as far as you can reach with your backhoe and then either pump or channel water into the excavation to physically determine if the pit will take water. I would expect a gravel zone or a cherty clay zone at some shallow depth below the surface around the well that could transmit water horizontally over to the well with vertical movement down the pipe.

SHEET 7 APPENDIX B

If the pit takes considerable quantities of water, it would be a matter of excavating all the way around the pipe to as deep as physically possible and then backfilling with a compacted clay soil with the material hand compacted against the casing to prevent water from moving downward. Hopefully, excavation on the outside of the casing would be deep enough to get below the point where water is moving over to the well.

This office does not have a record of those wells as to depth of soil, total depth of well, and/or the casing point. I suspect, however, that if water is moving over to the well, that it would be a shallow situation i.e. 5-15 feet rather than something taking place at 30-40 feet.

In summary, we evidently still don't know where the main mass of water movement is taking place and it may well be a combination of the one well in the valley bottom taking a quantity of water as well as leakage under and around the dam that is observable. Patching or correcting either of which may well reduce the leakage to the point where it is acceptable as far as fluctuation of the water line is concerned. I would appreciate it if you would let me know the results of attempting to promote vertical water flow on the outside of the casings in the upper end of the lake.

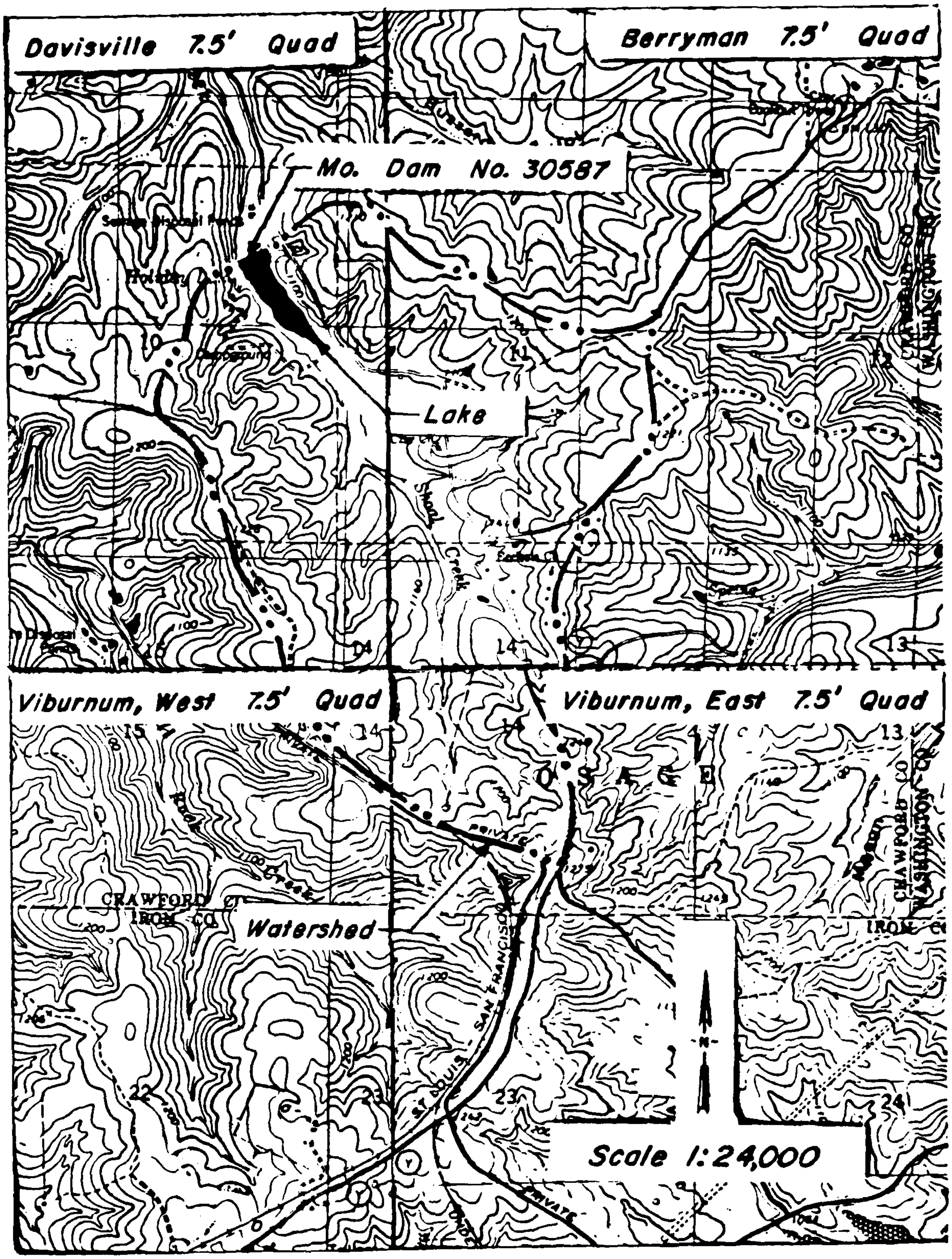
Yours truly,

Thomas J. Dean

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey

TJD/dsb

APPENDIX C



LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULIC AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. The caretaker indicated that the dam has never been overtopped and that the emergency spillway has operated twice since the dam was built. In April 1979, it operated with about 1 ft of head and in 1975 or 1976 about 1.5 ft. On the day of the inspection, there was no indication of overtopping. High water marks were found at elevation 1068.9 (0.70 ft above emergency spillway crest).

Visual Inspection: At the time of the inspection, the pool level was approximately 0.70 ft below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the following Missouri 7.5 minute U.S.G.S. quadrangle maps: Davisville, Berryman S.E., Viburnum East, and Viburnum West. The storage volume was developed from these data. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 1636 c.f.s. and a time to peak of 25 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 12,352 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 25 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (small size with high downstream hazard potential) pass 50 to 100 percent of the PMF, without overtopping. Considering the size of the dam, the small storage capacity and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood.

The routing of 50 percent of the PMF through the spillway and dam indicates that the dam will be overtopped by 1.34 ft at elevation 1073.14. The duration of the overtopping will be 0.92 hours, and the maximum outflow will be 6006 c.f.s. The maximum discharge capacity of the combined spillways is 2538 c.f.s. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrograph for the 50 percent PMF flood are presented on Sheets 5, 6 and 7 of Appendix C.

OVERTOPPING ANALYSIS FOR HOLIDAY LAKE DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
   Hydraulic Inputs Are As Follows:

   a. Twenty-four Hour Rainfall of 26.7 Inches For 200 Square Miles - All Season Envelope

   b. Drainage Area = 909 Acres; = 1.42 Sq. Miles

   c. Travel Time of Runoff 0.63 Hrs.; Lag Time 0.38 Hrs.

   d. Soil Conservation Service Soil Group B

   e. Soil Conservation Service Runoff Curve No. 75 (AMC III)

   f. Proportion of Drainage Basin Impervious .02

2. Spillways

   a. Primary Spillway: Rectangular Concrete Weir;
      Length 14 ft; C = 3.1

   b. Emergency Spillway (Grass-Lined, Trapezoidal Cut
      Length 60 Ft.; Side Slopes 7.5:1 28.5:1 C = Varies

   c. Dam Overflow
      Length 380 Ft.; Crest El. 1071.8 ; C = 3.0

3. Spillway and Dam Rating:

   Curve Prepared by Hanson Engineers. Data Provided To Computer on Y4 and Y5 Cards. (Sheet 5, Appendix C)
   Formula Used: Primary Spillway and Dam $Q = CLH^{1.5}$
   Emergency Spillway $\frac{Q^2}{g} = \frac{A^3}{T}$

Note: Time of Concentration From Equation $Tc = \left(\frac{11.9\ L^3}{H}\right)^{.385}$
California Culvert Practice, California Highways and Public Works, Sept. 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph

   a. Peak - 1636 c.f.s.

   b. Time to Peak 25 Min.

2. Flood Routings Were Computed by the Modified Puls Method

   a. Peak Inflow

      50% PMF 6176 c.f.s.; 100% PMF 12,352 c.f.s.

   b. Peak Elevation

      50% PMF 1073.14 100% PMF 1074.67

   c. Portion of PMF That Will Reach Top of Dam

      25 %; Top of Dam Elev. 1071.8 Ft.

3. Computer Input and Output Data are shown on Sheets 5 and 6 of this Appendix.

```
A       OVERTOPPING ANALYSIS FOR HOLIDAY LAKE DAM ( # 16 )
A       STATE ID NO. 30587  CO. NO. 055  CO. NAME CRAWFORD
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
B    300                 5
B1     5
J      1       7       1
J1   .15     .20     .30     .40     .50     .75     1.0
K      0       1                               3       1
K1      INFLOW HYDROGRAPH COMPUTATION
M      1       2    1.42            1.42       1                       1
P      0    26.7     102     120     130
T                                                     -1     -75              0.02
W2  0.63    0.38
X      0     -.1       2
K      1       2                       0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE
Y                              1       1
Y1     1                                              70      -1
Y4  1067  1068.2    1069    1070    1071  1071.8    1073    1074    1075
Y5     0      57     293     865    1697    2538    4042    5487    7111
$A     0      11      17      27
$E  1048    1067  1071.8    1080
$$  1067
$D1071.8     3.0     1.5     380
K     99
```

P.M.F. Input Data
Sheet 5 Appendix C

********** ********** ********** ********** **********

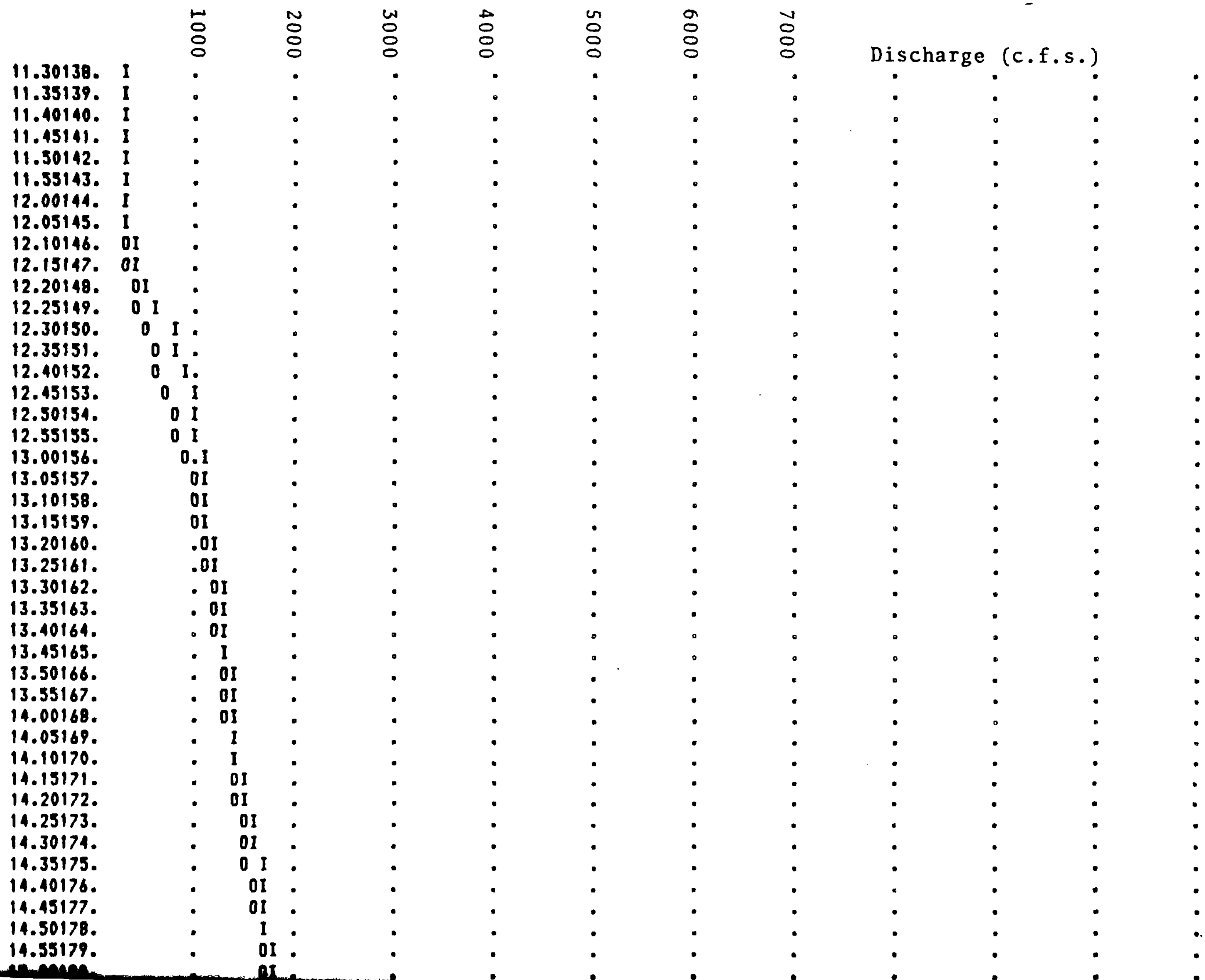
PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

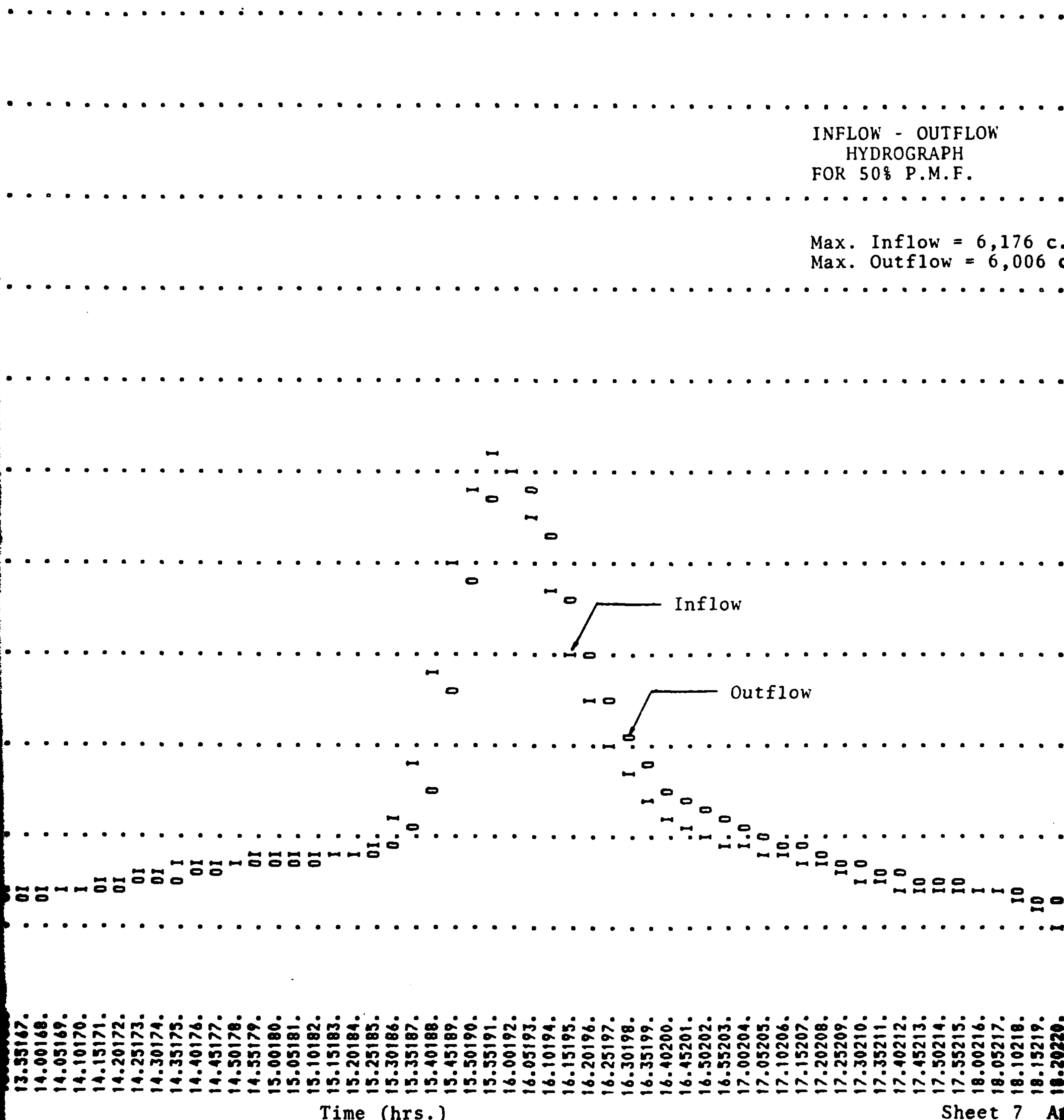
				RATIOS APPLIED TO FLOWS						
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
				0.15	0.20	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	1.42	1	1853.	2470.	3706.	4941.	6176.	9264.	12352.
	(	3.68)	(	52.47)(	69.96)(	104.93)(	139.91)(	174.89)(	262.33)(	349.78)(
ROUTED TO	2	1.42	1	1552.	2127.	3418.	4738.	6006.	9075.	12132.
	(	3.68)	(	43.94)(	60.22)(	96.80)(	134.18)(	170.07)(	256.96)(	343.55)(

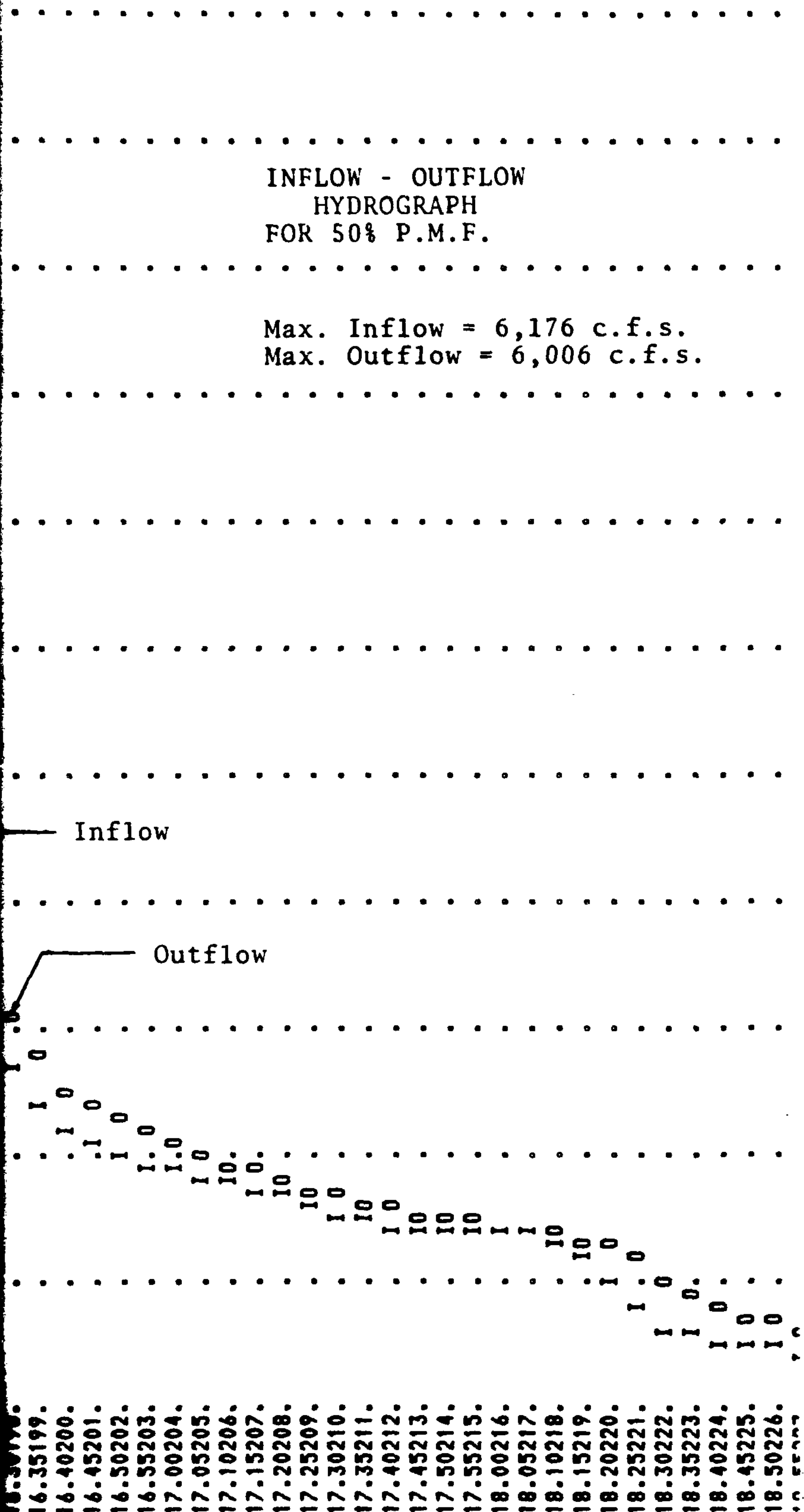
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1067.02	1067.00	1071.80
STORAGE	70.	70.	136.
OUTFLOW	1.	0.	2538.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.15	1070.83	0.00	120.	1552.	0.00	16.08	0.00
0.20	1071.41	0.00	130.	2127.	0.00	16.08	0.00
0.30	1072.24	0.44	144.	3418.	0.50	16.08	0.00
0.40	1072.73	0.93	153.	4738.	0.75	16.00	0.00
0.50	1073.14	1.34	160.	6006.	0.92	16.00	0.00
0.75	1073.97	2.17	176.	9075.	2.50	16.00	0.00
1.00	1074.67	2.87	190.	12132.	4.58	16.00	0.00


1000
2000
3000
4000
5000
6000
7000
Discharge (c.f.s.)
11.30138.
11.35139.
11.40140.
11.45141.
11.50142.
11.55143.
12.00144.
12.05145.
12.10146.
12.15147.
12.20148.
12.25149.
12.30150.
12.35151.
12.40152.
12.45153.
12.50154.
12.55155.
13.00156.
13.05157.
13.10158.
13.15159.
13.20160.
13.25161.
13.30162.
13.35163.
13.40164.
13.45165.
13.50166.
13.55167.
14.00168.
14.05169.
14.10170.
14.15171.
14.20172.
14.25173.
14.30174.
14.35175.
14.40176.
14.45177.
14.50178.
14.55179.


INFLOW - OUTFLOW
HYDROGRAPH
FOR 50% P.M.F.
Max. Inflow = 6,176 c.
Max. Outflow = 6,006 c
Inflow
Outflow
13.55167. 14.00168. 14.05169. 14.10170. 14.15171. 14.20172. 14.25173. 14.30174. 14.35175. 14.40176. 14.45177. 14.50178. 14.55179. 15.00180. 15.05181. 15.10182. 15.15183. 15.20184. 15.25185. 15.30186. 15.35187. 15.40188. 15.45189. 15.50190. 15.55191. 16.00192. 16.05193. 16.10194. 16.15195. 16.20196. 16.25197. 16.30198. 16.35199. 16.40200. 16.45201. 16.50202. 16.55203. 17.00204. 17.05205. 17.10206. 17.15207. 17.20208. 17.25209. 17.30210. 17.35211. 17.40212. 17.45213. 17.50214. 17.55215. 18.00216. 18.05217. 18.10218. 18.15219. 18.20220.
Time (hrs.)


INFLOW - OUTFLOW
HYDROGRAPH
FOR 50% P.M.F.
Max. Inflow = 6,176 c.f.s.
Max. Outflow = 6,006 c.f.s.
Inflow
Outflow
16.35199.
16.40200.
16.45201.
16.50202.
16.55203.
17.00204.
17.05205.
17.10206.
17.15207.
17.20208.
17.25209.
17.30210.
17.35211.
17.40212.
17.45213.
17.50214.
17.55215.
18.00216.
18.05217.
18.10218.
18.15219.
18.20220.
18.25221.
18.30222.
18.35223.
18.40224.
18.45225.
18.50226.

APPENDIX D

INDEX TO PHOTOGRAPHS

Photo No.	Description
1.	Aerial - Lake and Watershed, Looking South
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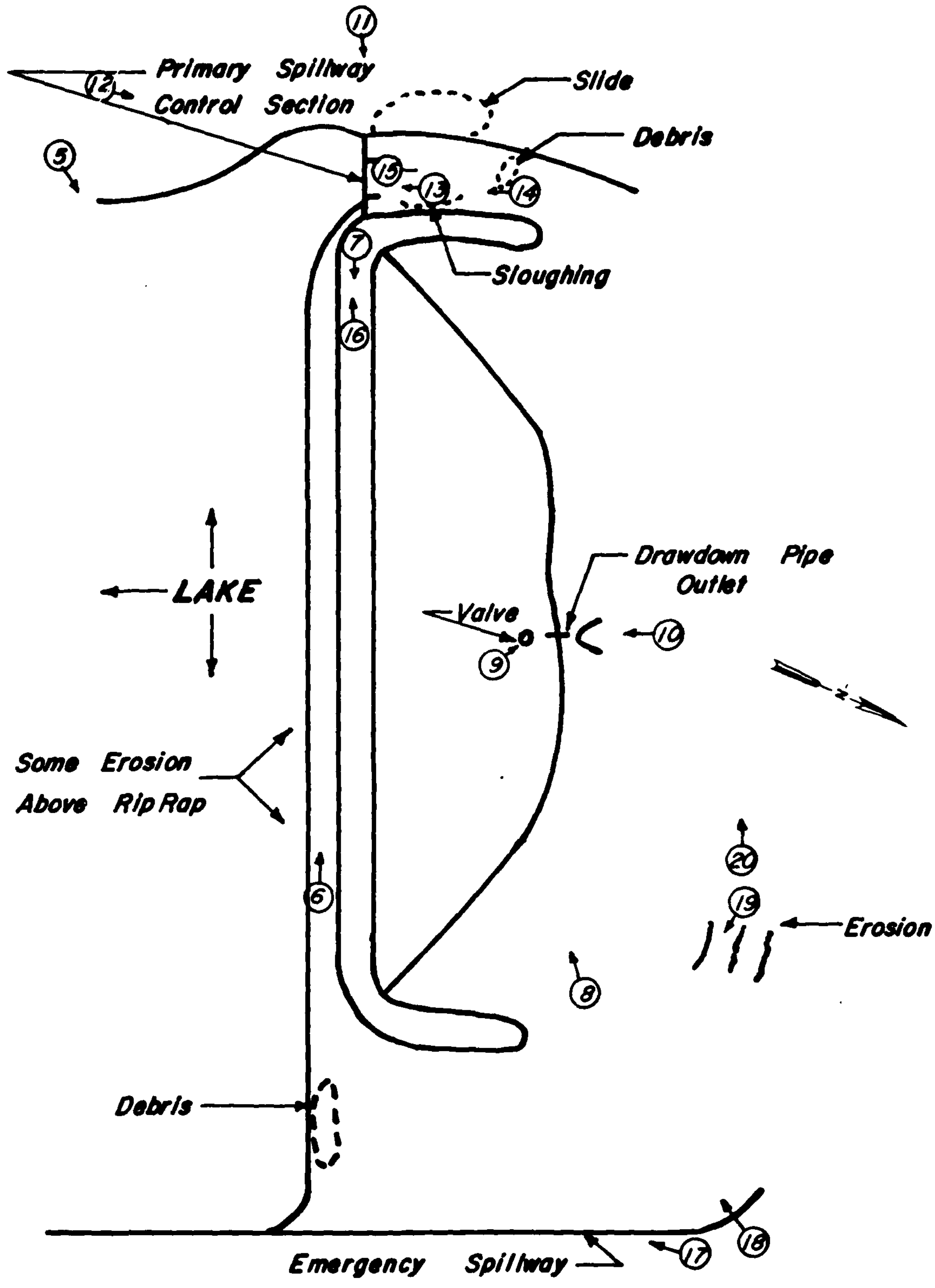
17.	Emergency Spillway Area, Looking Upstream
18.	Emergency Spillway Area
19.	Emergency Spillway, Looking Upstream
20.	Emergency Spillway, Looking Downstream



DRAWN	DER
CHECKED	DLK
DATE	8-1-79
JOB NO.	79511

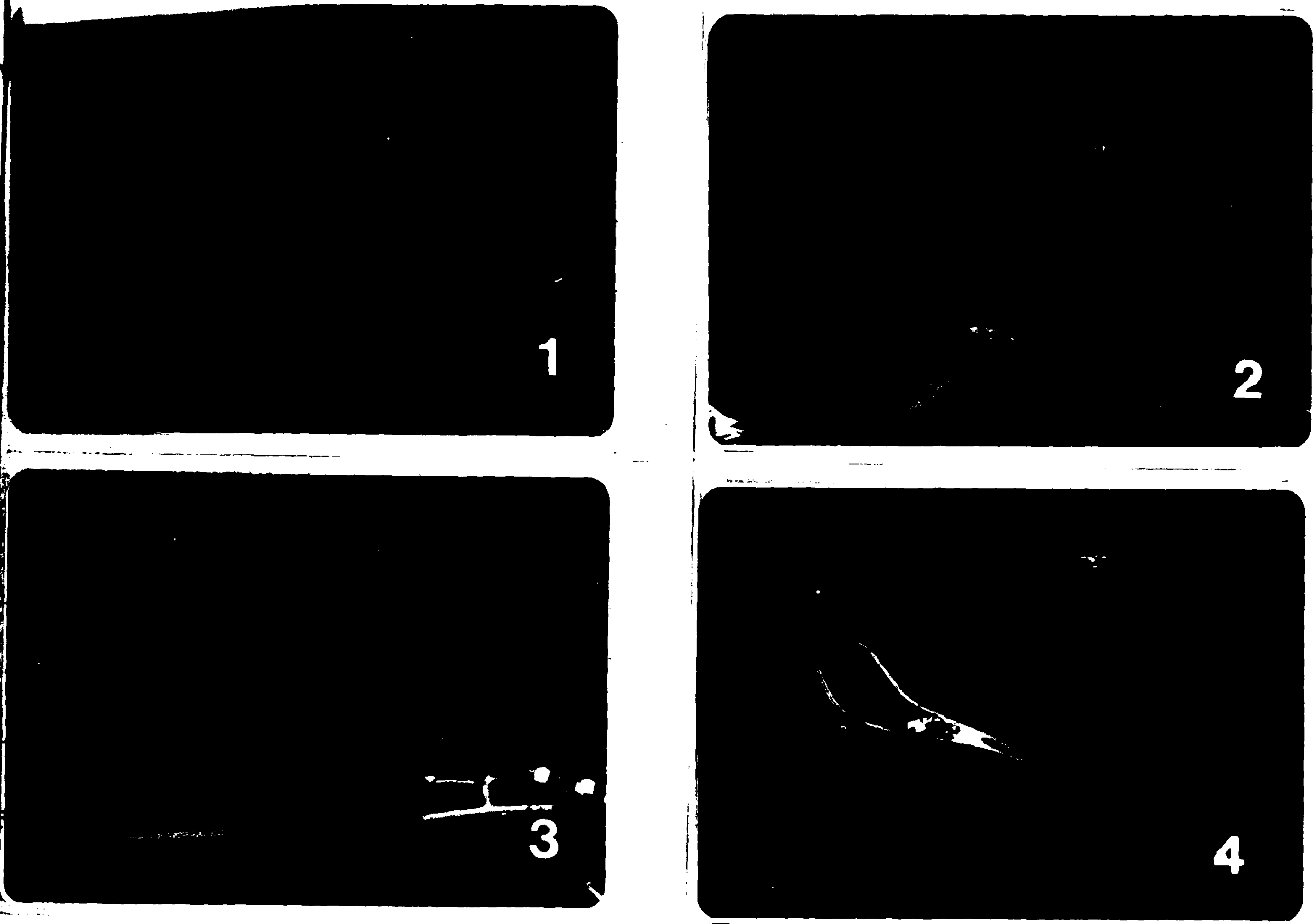
HANSON ENGINEERS

SPRINGFIELD ILL. PEORIA ILL.

Plan Sketch

Key To Photographs

Sheet 2 Appendix D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4


5


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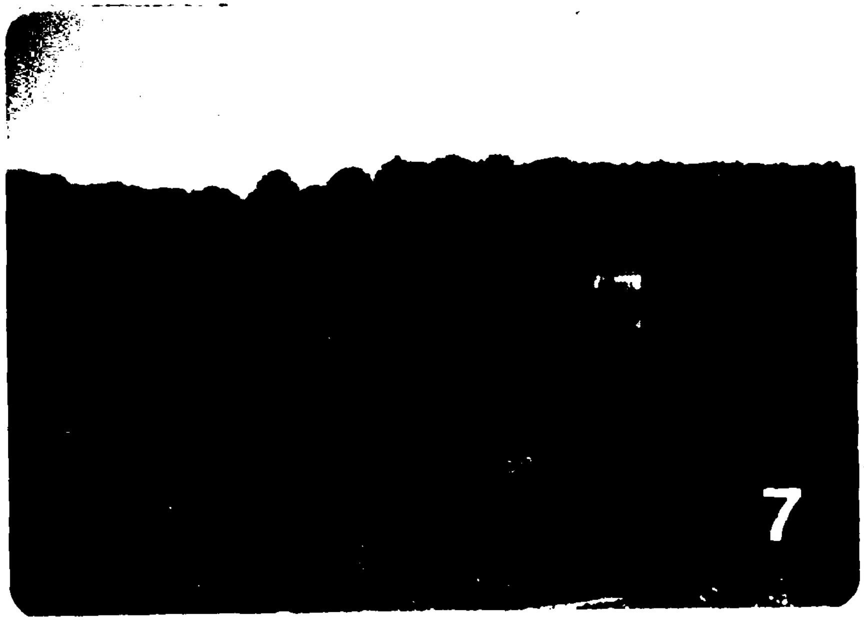
7





19


18


17

END
DATE
ILME